ADMINISTRATOR DR. KATHRYN SULLIVAN'S REMARKS AT THE
AMERICAN METEROLOGICAL SOCIETY'S ANNUAL MEETING
AS PREPARED FOR DELIVERY

January 5, 2015
11:00 a.m. EST

Thank you, Kim, for that nice introduction.

I'm delighted to be invited to launch this morning's sessions with such a fascinating and challenging discussion – one that I expect will ripple throughout the entire meeting.

I've pondered a lot of things as I prepared for this conversation:

- The cautionary words of Niels Bohr and Yogi Berra, both of whom supposedly said, "predictions are hard to make, especially when they're about the future."
- But also the words of Google founder Larry Page, who said he thinks most companies fail because they miss the future.
- And, finally, the practical wisdom of hockey great Wayne Gretzky, who said the secret to his success was that he skated to where the puck was going to be.

So, I salute President Bill Gail for bringing us together to consider the future of our profession and our enterprise. And I commend him for the innovative design of this session, which is essentially a living "ensemble forecast" look into that future.

I am sure I will gain at least as much insight from my fellow panelists and all of you as I will offer, which will help me do all that I can to insure that NOAA is looking far down the ice and skating to where the puck will be 25 years from now.

My aims today are simple: to offer some context and framing for our discussion; to reflect on several of the major drivers shaping our world today, and what they may mean to this future; to question, ponder and imagine with you what the implications of this are for our products, services, business models and skill mixes.

I see this as a thought experiment we are all doing together, and my comments are offered in that vein. No policy shifts or programmatic direction are intended or implied by my remarks.

So, anticipating 2040; 25 years from now. That's not a very long span of time for the planet we live on. It's a more significant span of time for us humans – nearly a full generation. But it's a tremendous span of time in the tech world – 16.7 generations, according to Moore's law.

A look back at the past 25 years – back to 1990 – can help attune us to the potential scale of change we might expect.

There was no Internet or World-Wide Web in 1990. Tim Berners-Lee had only written the memo that would spawn the creation of these world-changing technologies the year before.

A “desktop computer” was called that because it quite literally filled an entire desktop. The IBM PC of the day ran at a blazing 4.77 Mhz, could be configured with up to 256 kB of memory and came equipped with two 5-inch floppy disk drives of 160kB each. Mobile phones were still novelties. Most were the size of a shoebox and weighed about 10 lbs. My first personal cell phone was only slightly smaller than a brick.

What about the weather enterprise?

At NOAA, we were just on the cusp of modernizing and restructuring the weather service - still 3 years away from installing the first NEXRAD prototype in Norman.

I think it’s fair to say that the private sector weather enterprise was in its infancy, and the public-private dynamic was far from constructive.

And if you wanted to know about the weather in those days, you picked up a newspaper or tuned into the nightly local news on one of the only four networks that existed.

If we’d had a similar session at the 1990 AMS meeting, we’d probably have made decent projections of how scientific and technological progress were likely to change the fundamentals of predicting the weather: how satellite and in situ sensors might improve our ability to sample the atmosphere; how research advances would help us eventually couple models of the atmosphere and ocean; how more powerful computers could let us model the Earth at finer scales and make longer-range forecasts; how future computer workstations might allow forecasters to assess and combine more information more rapidly to produce better forecasts.

But I bet we wouldn’t have foreseen many of the changes that make our world what it is today.

The changes in networking, computing, storage and personal devices that make data and computing power so much more ubiquitous today, and so taken for granted. Not to mention the related, radical changes in mass media business models that we've witnessed, or the shift of bleeding-edge digital innovation from government labs to the consumer sector. Last, but far from least, the myriad changes in consumer and user behaviors all of these have enabled. This should remind us, as we now try to anticipate 2040, to keep the human dimensions of change in focus along with the scientific and technological ones.

We can say some things about the world of 2040 with fair certainty:

- The planet will be warmer, leading to more extreme weather and water events, and more intense extremes.

- Observations will still fuel environmental forecasting. Ours will never be solely a data mining enterprise (though data mining and analytics will likely play larger roles in the future).
- The planet's population will have increased from today's 7 billion to just nearly 9 billion – an increase of 28%.
- Resource margins will be stretched even thinner and strains even greater on water, food, energy and ecosystems.

Which brings me to the one specific prediction I will make: The water-food-energy nexus will be a critical issue of the times in 2040.

And, as today, it will probably still be true that very few people actually care about weather and climate per se, or about how we in this profession understand and predict them.

Most people will continue to care about the health, safety and prosperity of their family, business or village. They will value what we do only insofar as it helps them protect or advance these basic elements, or how it brings greater comfort, convenience, efficiency to their lives. Their expectations of us will be shaped by this basic reality.

The bottom line: The need for and utility of Environmental Intelligence – timely, reliable, actionable information that is pertinent to real-world lives - will be greater than ever before. We have a very strong value proposition.

So, what will the weather enterprise look like in 2040? We can't possibly know. But we can up our chances of a Gretzky-like anticipation of where it's going by considering some of the driving forces that will shape it.

So let's think a bit about (a) the demand function: What will people need and want? and (b) The production equation: How Environmental measurements and basic scientific understanding get transformed into the Environmental Intelligence people need, and then consider some of the broad implications for our enterprise.

Current drivers suggest that demand for the kind of insight and foresight our enterprise provides will only grow over the next two and a half decades.

But they also suggest significant changes in exactly what society – our customers – will want and need from us, and growing expectation that *THEY* get to define – and customize – *THEIR* product or service.

How will we meet this trend towards hyper-localization and personalization?

Will anybody still want a *weather forecast* per se? Will they instead want an integrated

environmental outlook, perhaps one that melds air quality and UV exposure with beach forecast and, oh yes, temperature and probability of rain?

Or will they not want any of those discrete products at all, but rather a super-smart planning app – think Personal Concierge – that knows their preferences and just serves up the best activity options for the day, factoring all the environmental variables in background?

(Wouldn't that be a boon to the AMS meeting planners of 2040! They could break the pattern of Annual Meetings being accompanied by oddly awful weather!)

Despite all of our current instrumentation, everybody here knows the atmosphere remains under-sampled. And if you think the atmosphere is under-sampled, consider the ocean – just the physical/chemical ocean, much less the living ocean.

Meeting the challenges and opportunities of tomorrow will take innovative new ways to sample the atmosphere, and radical improvements in today's ocean and terrestrial observations.

We see some elements of this progression around us today: bringing dual-polarization to the NEXRAD system; partnering with the US Integrated Ocean Observing System (IOOS) regional associations to increase ocean observations and benefit wave and inundation modeling; evaluating ocean gliders and other new technologies that may someday supplant the existing TAO array; taking the next steps forward in space-based atmospheric sounding and severe weather surveillance via the JPSS and GOES-R spacecraft that are in production today.

But what big drivers might transform the observing architecture more radically?

Another driver we see emerging around us is the increasing use of drones. We already use drones to gather environmental data that are dangerous or extremely difficult to collect any other way. For example: This past hurricane season saw the first operational use of Global Hawk dropsondes. The data were assimilated into the HWRF model and had a positive impact on track and intensity forecasts. Drones also fly into remote Arctic regions to collect climate data that ships and buoys can't provide; monitor currents and ocean properties in areas of high variability; collect critical high-resolution data needed to improve and downscale regional models of processes affecting both weather and local fisheries; monitor marine mammal distribution to help us manage living marine resources.

Couple extreme autonomy with miniaturization and other emergent technologies, and you get even more interesting prospects for transforming Earth observations: Swarms and crowds.

- Wearable sensors, incorporated into jackets, hats, swimsuits, could help calibrate hyper-local forecasts. (And what's the computing model in this case? Surely not that all of this comes back to NOAA to get put into the next model run.

- Motes - those tiny, wireless, sensing networks - are actively being pursed in NSF's ecological observatories (NEON) for environmental monitoring. If you want to join the fray, you can buy a Blue-tooth environmental mote for your smartphone today, for just $39. Motes could transform urban meteorology, air quality monitoring, dispersion analysis.

- Bio-mimicry: It has already been demonstrated, for example, that virus-based bundles detect toxicants and pathogens calorimetrically. Imagine using this approach to detect harmful algal toxins or other contaminants that could affect public water supplies.

(An aside: Patents containing the work "biomimetic" or "bio-inspired" jumped by 93-fold between 1985 and 2005, slightly longer than the timespan we're considering today. In contrast, other patents grew just 2.7-fold).

What would be the most powerful applications of such pervasive sampling in our enterprise?

Many potential societal uses of environmental intelligence require forecasts (or outlooks) on time and space scales we cannot currently provide For example, our emergency management partners tell us that 8-14 day advanced warning of extreme heat predictions would improve public preparedness significantly; today's outlooks are 6-10 days. Water managers would love to have reliable total water forecasts at seasonal to annual scales, and reliable long-term supply outlooks at 5 to 10 year scales. Reliable decadal scale outlooks of key variables would be a boon to infrastructure planners of all stripes.

We can't provide these right now because there's a science gap between the capabilities of our weather forecasting and our climate prediction capabilities. Closing this gap will require both further research into key physical processes and better model representations. Some key areas needing focus are:

- Rigorous representations of all aspects of the hydrologic cycle and for the role of aerosols and other significant chemical species in the atmosphere;
- Development of cloud-resolving (atmospheric) model representations for local to global scales.
- Realistically resolving the 4-D eddy structure of our ocean models globally, at scales down to 10km or less.
- Learning how to design ensembles for longer-lead weather and shorter-term climate forecasts and validate model results across the continuum.

As for delivering forecasts at impact-relevant scales, current computational trends will certainly make minute-scale, km-resolution models possible in the very near term. But how will we tackle the data assimilation and cal/val challenges that pervasive and crowd-sourced sensing may pose?

How all of this will play out depends critically upon the high-performance computing infrastructure of the future. Our enterprise is not the market maker here; we do not shape the future of computing. And the folks that do shape it project radical transformations coming in the next few decades. From what we know today to cognitive computing, a pervasive internet of things and a computing continuum. How will those transform not only *WHAT* we can do, but also *HOW* and *WHERE* we do it – and maybe even who the *WE* in that sentence is! I look forward to hearing more from Mac Devine about this.

While I'm on the subject of computing, let me step away from future-think for a moment to share some exciting news with you: NOAA is announcing significant investment in the next generation of supercomputers. This investment is the next phase in our continued efforts to provide more timely, reliable, and detailed forecasts. By October of this year, the capacity of each of our super computers will jump nearly 10-fold, to a total of 5 petaflops. Come to the town hall that follows this session or stop by the NOAA booth to get more details.

If you've been paying attention, you'll have noticed that I haven't offered any solid insight at all about how the many drivers of change in environmental monitoring, earth system science crowd- and swarm-sourcing or cognitive computing are going to change our business by 2040.

But I did offer one specific prediction. It is one that I am very confident will verify, and that tells us a good bit about our enterprise in 2040. The water-food-energy nexus to society will surely loom as a major global challenge in 2040. And tied directly to this is the viability of the natural environment upon which all of life on Earth depends.

Society – from heads of households to corporate leaders and heads of state – will be hungry for environmental intelligence that helps them build better answers to the daunting questions they are facing – about the safety of their citizens, viability of their companies, future of their children.

Given this, all of us here in this room should feel pretty good about what the future holds for us as individuals: An abundance of challenging, meaningful and satisfying work is in store for us! The big uncertainty facing us as individuals is how the profound changes in consumer preferences, pervasive computing and so on may scramble the specific pattern of jobs and skill mixes that we know today. Is the forecaster of the future more involved in decision support and advisory services to communities or clients than in isobars, fronts and grids? Is she a "weather" expert or an "Earth systems" expert? Is the new academic preparation something like 50% physical science, 30% social science and communications and 20% sector-specific hazard and impact analysis? At the 2040 meeting, what will be the ratio of Kim Klockows and Curtis Walkers to Bill Gails and Louis Uccellinis?

Far greater uncertainty lies along another axis: How will the next 25 years treat the government agencies, companies and universities that constitute the enterprise today?

Clearly none of those three categories will disappear altogether. But when we meet at AMS in 2040, we will very likely be talking about a few entities within each category that were the most prescient, that sensed the future and leaned into it, becoming agents of innovation and change.

We'll talk about others who've just been along for the ride, and then reflect on the sad cases of those that stuck their heads in the sand or clung so tightly to their *status quo* that they're struggling to survive.

What will we be discussing at the 2040 Presidential forum? I hope we're reflecting on how we morphed from the weather business of the 20th century into a rich and seamless environmental intelligence enterprise. An enterprise that is nimble and innovative; whose products and services are woven into societal, corporate and individual decision-making in ways we cannot imagine today. An enterprise that is widely regarded as the platinum-grade example of an effective, dynamic public-private-academic partnership. And that draws the best talent from every segment of our population and all corners of our country.

This could well be the subject of AMS 2040. But so could its evil twin, the "Tale of Decay and Obsolescence". Which of those future prospects comes to pass will be a function of leadership. It will take leadership in all segments and at all levels of our enterprise – leadership that does not fear the future but engages and shapes the future – to achieve the rosier outcome.

Our work has never been more important. Our opportunities have never been greater. Let this AMS, and each of the next 25, be about skating together to where the puck is going to be.

###